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Study on compressive strength relationship between basalt fiber and rubber ceramsite concrete

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Abstract

Since the reform and opening up, China has achieved rapid economic growth. Since entering the 21st century, China's science and technology have been constantly innovating, bringing us more advanced technology and a better experimental environment. At the same time, it also promotes development and innovation in the field of architecture. This experiment is to explore the effect of adding basalt fiber to rubber ceramsite concrete on the compressive strength of concrete. Basalt fiber, as a new type of green fiber, has the advantage of good quality and low price, and has a broad market application prospect. As a lightweight concrete material, the performance of rubber ceramsite concrete weakened by the addition of rubber has been restored after the addition of basalt fiber. The test results show that the addition of rubber weakens the mechanical properties of ceramsite concrete to a considerable extent, while the addition of basalt fiber can significantly improve the compressive strength of specimens and restore the corresponding mechanical properties.

Keywords

Rubber concrete;Ceramsite;Basalt fiber;The compressive strength.

1. Introduction

Since 1848 when reinforced concrete was invented, people have studied and applied its function, and concrete has developed efficiently and continuously in the field of architecture. With the continuous progress of science and technology, the continuous innovation of building materials, new concrete gradually into people's vision. In recent years, China's rubber consumption has been ranked first in the world, rubber is an important raw material to support China's industrial development, but the domestic rubber resources lack, 70% of rubber still need to import, in the world's rubber consumption, the rubber industry has consumed more than 80% of the world. In the whole rubber products, about 65% of the rubber is used in the automotive industry, the use of rubber is also the most. Even the amount of glue used by a car has exceeded 100 kilograms, among which the tire is 37.8 kilograms[1-3].

With the continuous development of the automobile industry, China's car ownership has been growing steadily year by year, the increase of disposable income of Chinese residents has also spawned the booming development of the automobile industry, more and more used cars, the disposal of used tires is particularly prominent. China produces 8 to 10 percent more used tires every year. In 2010, about 250 million tires were produced in China, and the recycling rate was only 50%, resulting in a huge waste of resources. Many scientists are carrying out multi-dimensional research on this

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black pollution, and some achievements have been achieved, including the secondary preparation of rubber [3], although the performance has been reduced. Some people study the reuse of automobile waste tires. After simple process treatment, small rubber particles are filled into ceramsite concrete as fine aggregate instead of river sand and used as light wall panels for assembled buildings. Basalt fiber is a new kind of green fiber material widely recognized and used[4-6]. However, the results are not ideal, the compressive strength and splitting tensile strength of the wall panel after adding rubber particles are obviously decreased, but the brittleness of ceramsite concrete is greatly improved, and the elastic modulus is greatly reduced. Because of this, in this paper, through experimental research by adding 0.2%, 0.4%, and 0.6% basalt fiber into ceramsite concrete with a rubber replacement rate of 10%, 20%, and 30%, respectively, to change the compressive strength of concrete and reduce the inhibiting effect of rubber on the compressive strength of concrete. New materials with low elastic modulus and good mechanical properties were prepared[7-8].

2. Test

2.1 Raw material parameters

Cement: The cement is made from Chongqing Huanxin Yanjing Cement Co., LTD. The production of composite Portland cement P.C42.5R, in line with the national "general Portland cement" (GB175-2007) in Portland cement requirements.

Ceramsite: clay ceramsite produced by Chongqing Caiyunshan Ceramsite Factory is adopted. See Table 1 for specific properties

Rubber: 16 mesh rubber produced by Sitong Rubber and Plastic Co., LTD., see Table 2 for specific parameters

Basalt fiber: the basalt fiber produced by Haining Anjie Material Co., Ltd. is used, and its specific performance indicators are shown in Table 3.

Table 1. Performance parameters of ceramsite

Particle diameter	Density grade	bulk density	water content	apparent density	water absorption
（mm）		（kg/m^3）	（%）	（kg/m^3）	（%）
0-10	500	476	16.63	758.97	5.53

Table 2. Performance parameters of rubber

Particle diameter	mean grain size	bulk density	ash content	apparent density	water absorption
（mm）	（mm）	（kg/m^3）	（%）	（kg/m^3）	（%）
0-1.18	1	1120	1<	1052	3<

Table 3. Performance parameters of basalt fiber

Operating Temp	sintering temperature	Linear Density	elasticity modulus	Density	tensile strength
（℃）	（℃）	（μm）	（GPa）	（kg/m^3）	（MPa）
-269-650	1050	7-15	91-110	2630-2650	3000-4800

2.2 The experimental method

According to GB/T50081-2019, the compressive strength was maintained for 3 days and 28 days respectively in a constant temperature curing box of (20+-) Celsius. The standard test method was

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used to measure the compressive strength. The sample size was 100mm*100mm*100mm, with 3 pieces in each group and 9 groups in total. Take the average of the calculated results[9-10].

$$f_c = \frac{F}{A} \tag{1}$$

Among them, f_c – Compressive strength of the sample (MPa);

F – Specimen failure load (N);

A – Specimen compression area (mm2).

2.3 Experimental mix

According to the applicable technical standards of lightweight aggregate concrete and the preliminary test, the optimal ratio is selected for the next qualification test, and the results are shown in the following table. Samples are numbered in the form of X-X-Y-Y-Z-Z, where X represents the content of basalt fiber, Y represents the length of basalt fiber, Y represents the specific number of basalt fiber length and Z represents the ratio of rubber content. Result analysis simplified the grouping into x-Y-Z form. Basalt fiber as admixture, by volume percentage directly added. Replace rubber particles, equal volume in proportion to replace river sand.

2.4 Sample preparation

Ordinary ceramsite concrete is prepared according to the Technical Standard for Application of Lightweight Aggregate Concrete (JGJ/T 12-2019).

Table 4. Mix proportion (kg / m3)

Materials / ID	ceramsite	cement	water	rubber	fly ash	dosage	length
X-0.2-Y-9-Z-10	777.86	375	160	21.5	83	0.2%	9
X-0.4-Y-9-Z-10	777.86	375	160	21.5	83	0.4%	9
X-0.6-Y-9-Z-10	777.86	375	160	21.5	83	0.6%	9
X-0.2-Y-9-Z-20	777.86	375	160	38.6	83	0.2%	9
X-0.2-Y-12-Z-30	777.86	375	160	57.9	83	0.2%	12
X-0.2-Y-18-Z-30	777.86	375	160	57.9	83	0.2%	18
X-0.2-Y-9-Z-30	777.86	375	160	57.9	83	0.2%	9
X-0-Y-0-Z-10	777.86	375	160	21.5	83	0	0
X-0-Y-0-Z-0	777.86	375	160	0	83	0	0

2.5 The appended drawings

The following sem images are the experimental materials or the experimental process:

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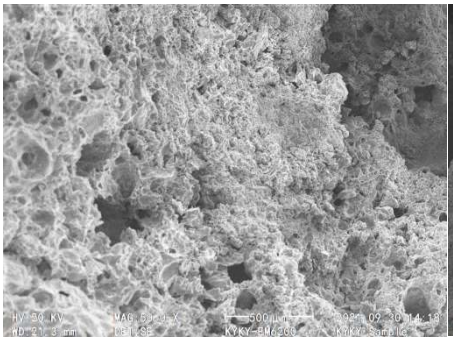

Fig .1 section

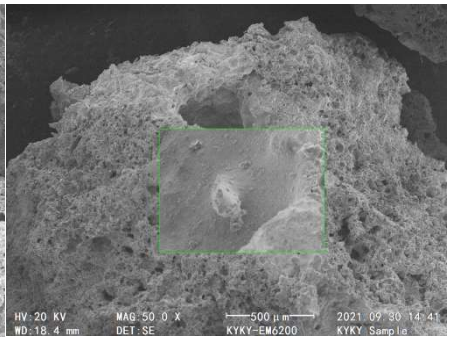

Fig .2 Combined with the interface

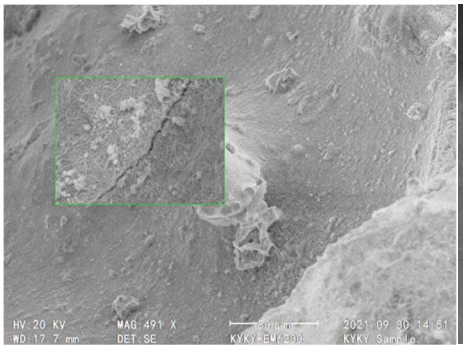

Fig .3 Hydration products

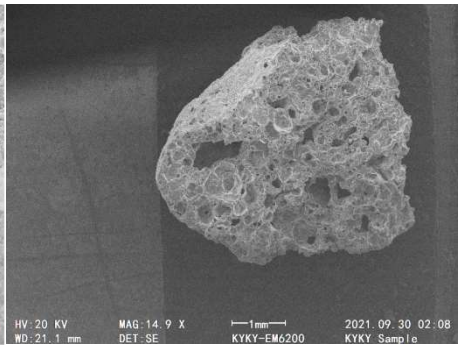

Fig .4 ceramsite

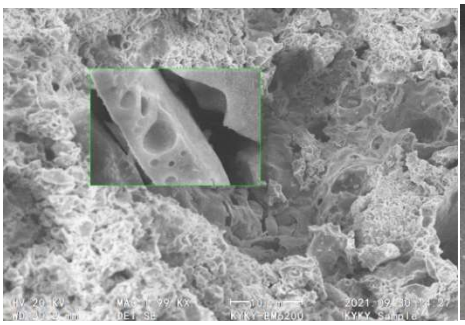

Fig .5 Basalt fiber

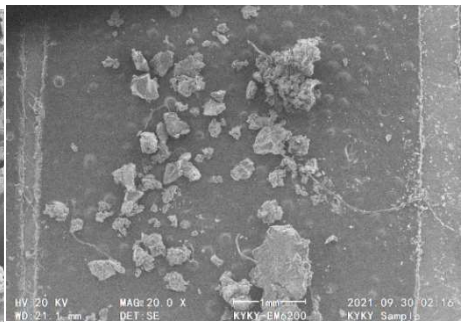

Fig .6 The rubber particles

3. Results

In this paper, the influence of the content of basalt fiber and the length of basalt fiber on the compressive properties of concrete is studied by using the method of replacing sand with rubber powder. All specimens in this paper were cured for 3d and 28d under standard conditions.

The research results show that the strength of rubber ceramsite concrete prepared by the method of equal volume sand replacement is lower than that of general concrete after adding rubber particles into ceramsite concrete. The specific research results are analyzed as follows:

Under the condition that the fiber length of basalt and the content of rubber particles remain unchanged, the compressive strength of rubber concrete specimens increases significantly with the increase of fiber content. The experimental results are shown in the figure below.

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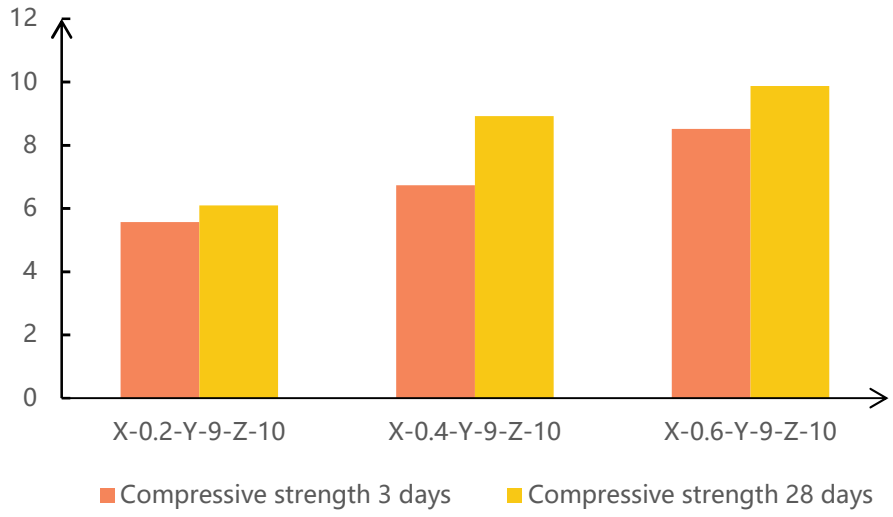

Fig 7. Curve of concrete compressive strength changing with basalt content

With the increase of rubber content, the compressive strength of ceramsite concrete will first increase and then decrease under the condition that the fiber length and the content of basalt remain unchanged. It can be inferred that there is a peak rubber content, so that the compressive strength of ceramsite concrete will reach the maximum at this replacement rate.

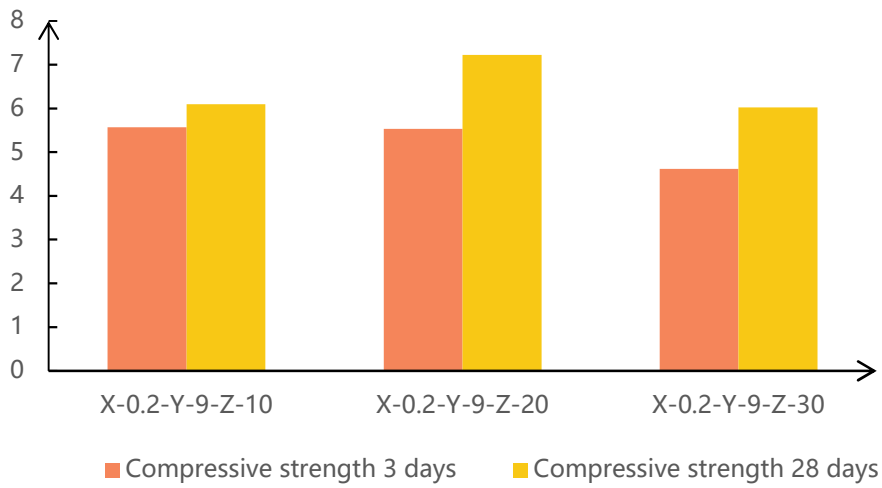

Fig 8. Curve of comprehensive strength with rubber content

When the content of basalt fiber and rubber remains unchanged, its curve is shown in the figure below. It can be observed that there is no significant difference between 9mm and 18mm, but the compressive strength of 12mm fiber length has significant increase. When curing for 28 days, the compressive strength of 12mm fiber length is the most obvious improvement. Compared with 9mm fiber length and curing for 28 days, the compressive strength of 12mm fiber length and curing for 28 days is increased by 28.57%, and compared with 18mm fiber length and curing for 28 days, the compressive strength is increased by 20.7%. Therefore, it can be considered that by comparing the fiber length of the three groups, at the fiber length of 12mm, the compressive strength of concrete at this time reaches the peak of the three experimental groups, and the whole trend of the compressive strength of concrete increases first and then decreases.

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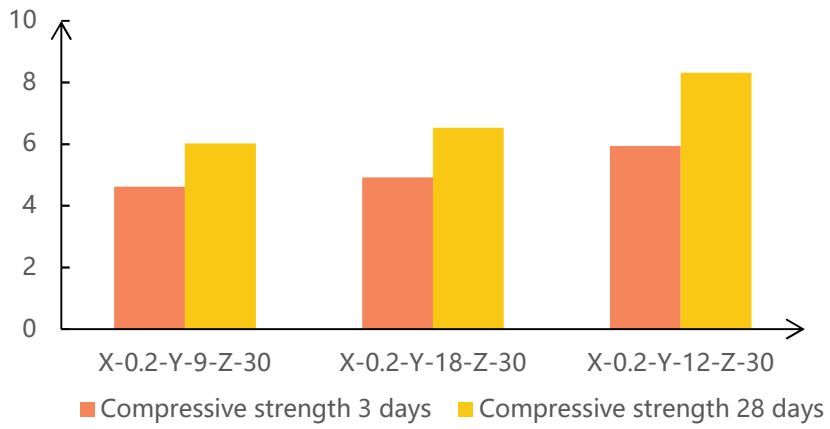

Fig 9. Curve of concrete comprehensive strength with fiber length

All the test specimens (including plain concrete control group) are shown in the figure below. It can be seen from the last group X-0-Y-0-Z-0 (plain concrete) in the figure that the biggest advantage of concrete is its high compressive strength. X-0-y-0-z-0 (plain concrete) can also be compared with X-0-Y-0-Z-10 (concrete with 10% rubber replacement rate), and it is found that after adding rubber particles, the strength of concrete has a very significant decline (whether 3-day curing or 28-day curing). In terms of 3-day curing, when adding 10% rubber content, The compressive strength of concrete decreased by 20.07%. Meanwhile, according to the comparison of other data, the compressive strength of concrete improved significantly when the basalt fiber length was 9mm. For the concrete control group x-0-Y-0-Z-10 (concrete with rubber replacement rate of 10%), after curing for 28 days, Their strength increased by 3.5%, 51.76% and 68.07%, respectively.

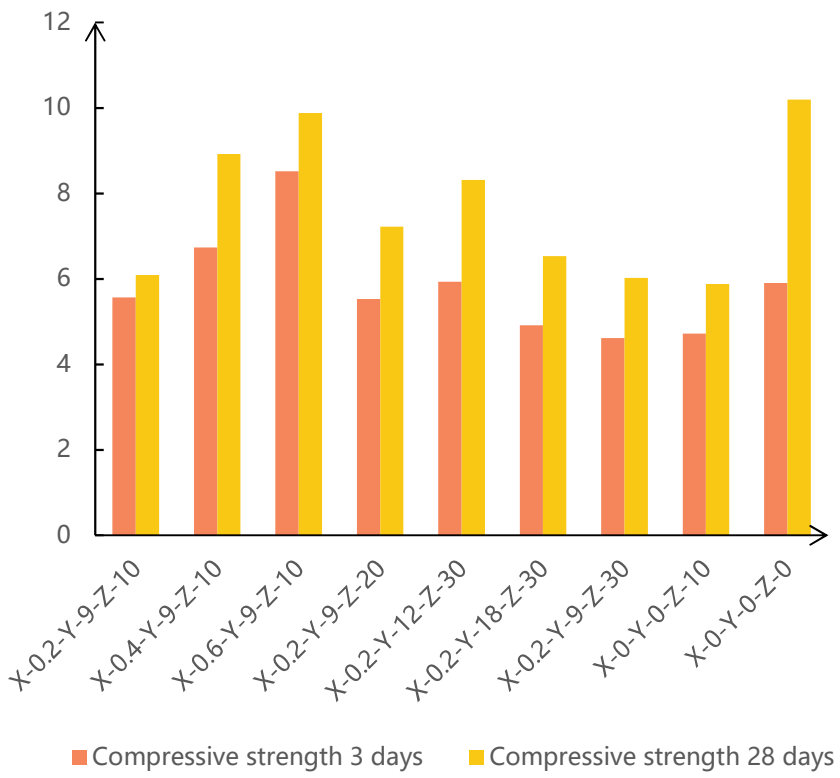

Fig 10. Concrete comprehensive strength curve of each group

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4. Conclusion

The content of basalt fiber can effectively improve the compressive strength of concrete. With the increase of rubber particle content, the compressive strength of concrete will increase first, and when it reaches a certain peak value, it shows a negative growth trend. The fiber lengths of 9mm, 12mm and 18mm were selected for the experiment, and 12mm was the optimal value of the compressive strength of concrete in this experiment. The experiment showed that in the three groups of experiments, when the fiber length of basalt was about 12mm, the compressive strength of concrete reached the maximum value, and its compressive strength improved significantly. Comprehensive, respectively, to join the concrete compressive strength of the specimens and the rubber particles and mixed with basalt fiber length for the comparison of compressive strength of the specimens of 9 mm, it is not difficult to draw, although rubber particles of ceramsite concrete brittleness has improved, but makes up the compressive strength is reduced, while to join after a certain amount of basalt fiber can effectively avoid this problem.

It can be seen that only adding rubber particles into ceramsite concrete can only realize the reuse of waste rubber and improve the elastic modulus of concrete by giving full play to the advantages of good toughness of rubber, but it has a negative impact on the compressive properties of concrete. However, in order to improve the compressive strength of concrete and reuse rubber particles, other materials need to be added. In this experiment, rubber particles are not only added to concrete as fine aggregate instead of river sand, but also to enhance the compressive strength and increase the elastic modulus of concrete by adding a certain amount of basalt fiber and grasping its incorporation length and amount. It is proved that basalt fiber is an effective blending agent for rubber ceramsite concrete.

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